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Comparative evaluation of organic wastes for improving maize growth and NPK content

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Plant residues being organic in nature are rich source of macro and micronutrients and can be recycled to prevent their disposal in the environment, thus sustaining the balance between economic development and environmental protection. The potential of three agricultural waste composts, farmyard manure (FYM), banana waste (BW) and pressmud (PM) was tested in a pot experiment growing maize. The results of the experiment showed highly significant increase in plant height, dry matter yields and NPK contents with the application of fertilizers, particularly nitrogen (N). Application of un-decomposed farmyard manure (UD-FYM), un-decomposed banana waste (UD-BW) and un-decomposed pressmud (UD-PM) generally depressed plant growth and dry matter yields as compared to control treatment. Maize growth, dry matter yields and NPK contents improved significantly when untreated compost (UC) or treated compost (TC) were added, but it was still below the fertilizer treatments. On comparative basis, maize response was better with PM, followed by FYM and BW. This study clearly shows the beneficial role of composted materials. It is suggested that further studies may be conducted on various aspects of composting technology, and integrated use of various composts and mineral fertilizers to determine their role in crop nutrition and sustainable production.

Key words: Composting, organic waste, farmyard manure, banana waste, pressmud.

INTRODUCTION

The disposal of large volumes of waste materials can be an expensive and environmentally threatening operation. However, if alternative uses can be found, disposal costs can be avoided and added economic value can be obtained from the usage of waste materials (Inckel et al., 1996; Sim and Wu, 2010). Pakistan, being an agricultural country, produces a huge amount of agro-wastes. Farmyard manure (FYM), banana waste (BW) and pressmud (PM) are very important agro-wastes in the province of Sindh. Banana is a major fruit crop of Pakistan with 85% banana area in Sindh (GOP, 2008).

After fruit harvest, the vegetative parts of banana are thrown away. Of the total nutrient contents of banana plant as a whole, BW contains almost 50% nutrients (Doran and Kaya, 2003) and another 50% nutrients are present in banana bunch. Only banana leaves contain 2.69% N, 0.15 to 0.2% P and 3.14 to 4.15% K (Lahav and Turner, 1983). Pressmud is discarded as a solid waste from sugar mills. About 1.2 million tons of PM are produced each year in Pakistan and dumped in the vicinity of factories (NFDC, 2004). Apart from being rich source of micronutrients, colloidal organic matter, it contains 2.2, 4.4 and 0.8% N, P and K respectively (Anwar et al., 2000). Farmyard manure is an excellent source containing all the plant nutrients needed for crop growth including trace elements. Approximately 70 to 80% of the N, 60 to 85% P and 80 to 90% of K in feed is excreted in the manure (Herbert, 1998). It is estimated that one ton of dropping of cattle, horses, sheep and poultry yield approximately 10 kg N, 16 kg P₂O₅ and 23 kg K₂O (Hussain, 2000).

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Abbreviations: FYM, Farmyard manure; BW, banana waste; PM, pressmud; UD-FYM, un-decomposed farmyard manure; UD-BW, un-decomposed banana waste; UD-PM, un-decomposed pressmud; UC, untreated compost; TC, treated compost.

Many strategies are being adopted to dispose organic wastes, yet it has to be safer for environment and sustainable for nutrient conservation. The composting technology is the rapid breakdown of organic matter, which produces humus (Parr et al., 1978). It is regarded as fully sustainable practice, since it aims at both conservation of the environment, human safety and economically convenient production. Composted material has more concentration of nutrients, narrower C : N ratio, free from pathogens and other potential contaminants that cause pollution (Zia et al., 2003; Jimenez and Wang, 2006). Incorporation of chemical fertilizers in composted materials improves its efficiency and reduces losses (Guar and Geeta, 1993). Application of PM improves soil structure, aeration, water holding capacity, porosity, increases stress tolerance and also reduces the use of chemical fertilizers (Hussain, 2000), thus saving huge amount of foreign exchange incurred for import of fertilizers (Yadav, 1991).

In view of the above considerations, this study was conducted to determine the value of composted FYM, BW and PM for growth and nutrition of maize, and also compare the effects of these waste materials with the recommended N, P and K fertilizer rates.

MATERIALS AND METHODS

Preparation of compost

Three compost materials FYM, BW (leaves and stalks) and PM were separately collected from banana plantation, cattle farm and local sugar mill of Sindh, respectively. Pressmud and farmyard manure each were thoroughly mixed for homogenization. In case of BW the leaves and stalks were chopped into 1 to 2 inch pieces before composting. The compost was separately prepared from these materials in a 1 m wide, 1 m long and 0.5 m deep pits lined with polyethylene sheet to avoid contamination and moisture loss. Two sets of compost materials were prepared, one set was treated with 1 kg urea per pit and the other was not treated. Both sets were covered with banana leaves to avoid losses of moisture. The compost mixture was turned /mixed on weekly basis for 11 weeks after recording the temperature for each treatment. A sample was collected from each treatment on weekly basis for moisture determination and its adjustment to 60% whenever necessary. The compost samples, taken after 11 weeks, were analyzed for N, P and K contents.

Pot experiment

The composted organic wastes were evaluated for their effect on growth and NPK nutrition of maize in a pot experiment involving 13 treatments which were replicated three times in a randomized complete block design. A surface soil (0 to 15 cm depth) developed from alluvial deposits was collected in bulk, air dried, sieved through 5 mm sieve and a 5 kg portion was placed in each of the 39 pots. A sub-sample was kept for soil physico-chemical analysis. Treatments included a complete control (T1), three inorganic fertilizer treatments N (75 mg N kg⁻¹ soil), NP (75 mg N kg⁻¹ soil + 37.5 mg P₂O₅ kg⁻¹ soil) and NPK (75 mg N kg⁻¹ soil + 37.5 mg P₂O₅ kg⁻¹ soil + 30 mg K₂O kg⁻¹ soil) as T2, T3 and T4, respectively, and three organic wastes (FYM, BW and PM) which were representing

un-decomposed (UD), untreated compost (UC) and the urea treated compost (TC). The organic wastes were applied to the designated treatments at the rate of 5 g kg⁻¹ soil. For fertilizer treatments, N was applied as urea (46% N) in three splits; P as single superphosphate (SSP, 20% P₂O₅) and K as sulphate of potash (SOP, 50% K₂O) were applied at few days after emergence of seedlings. Ten seeds of maize (cultivar Akbar) were planted in each pot and after the emergence, only six seedlings were maintained in each pot in such a way that every plant was far away from each other at equal distance. The plants were harvested at seven weeks after planting. Plant height was recorded before harvesting and dry weights after drying the plants at 70°C. The plant samples were ground and stored for analysis.

Soil, plant and compost analysis

The soil used for pot experiment was analyzed for electrical conductivity (EC) and pH in 1:5 soil water extract, texture by Bouyoucos hydrometer method, organic matter by Walkley-Black method, available P by NaHCO₃ (Olsen et al., 1954), followed by ascorbic acid color development method (Murphy and Riley, 1962), while extractable K was measured by extraction with 1 N NH₄-acetate (Knudsen et al., 1982).

Compost and the plant samples were analyzed for N, P and K. Total N was determined by Kjeldahl's method by digesting the contents in H₂SO₄ followed by distillation (Jones et al., 1991). Phosphorus and K were determined by digesting the samples in 1:5 HClO₄:HNO₃ mixture. The digests were analyzed for P by vanadomolybdo phosphoric acid yellow color method (Cottenie, 1980) and K by emission spectroscopy. Statistical analyses of the data were performed using SAS version 9.0 (SAS, 2003).

RESULTS AND DISCUSSION

NPK contents of composted materials

The analytical data regarding NPK contents of FYM, BW and PM showed great variation depending upon the nature of material (Figures 1 to 3). Nitrogen contents of UD-FYM, BW and PM were 14.0, 20.0 and 20.0 g kg⁻¹, respectively. In case of P, PM was the richest source containing 13.5 g kg⁻¹ followed by FYM (2.9 g kg⁻¹) and BW (2.0 g kg⁻¹). A different picture emerged for K, which was highest in banana waste (38.0 g kg⁻¹) followed by FYM (21.0 g kg⁻¹). PM was lowest (9.4 g kg⁻¹) in K as compared to other two materials. These results compare well with those of Shah (2001) who also reported highest contents of P (17.4 g kg⁻¹) in PM and K (24.0 g kg⁻¹) in FYM. There was increase in the overall nutrient contents after composting. Comparing the TC contents with UD, the N content was generally more in TC material of BW (27.3 g kg⁻¹) and FYM (17.5 g kg⁻¹) but in case of PM, the N contents (19.4 g kg⁻¹) were only slightly lower than the UD of PM (20.0 g kg⁻¹). This may be related to high degree of temperature during initial weeks and subsequent decomposition/loss of N (Martins and Dewes, 1992). The P content was highest (14.6 g kg⁻¹) in TC material of PM followed by FYM (3.6 g kg⁻¹) and BW (2.3 g kg⁻¹) than the contents in UD material. As for K, BW (51.0 g kg⁻¹) and PM (14.6 g kg⁻¹) had highest content in

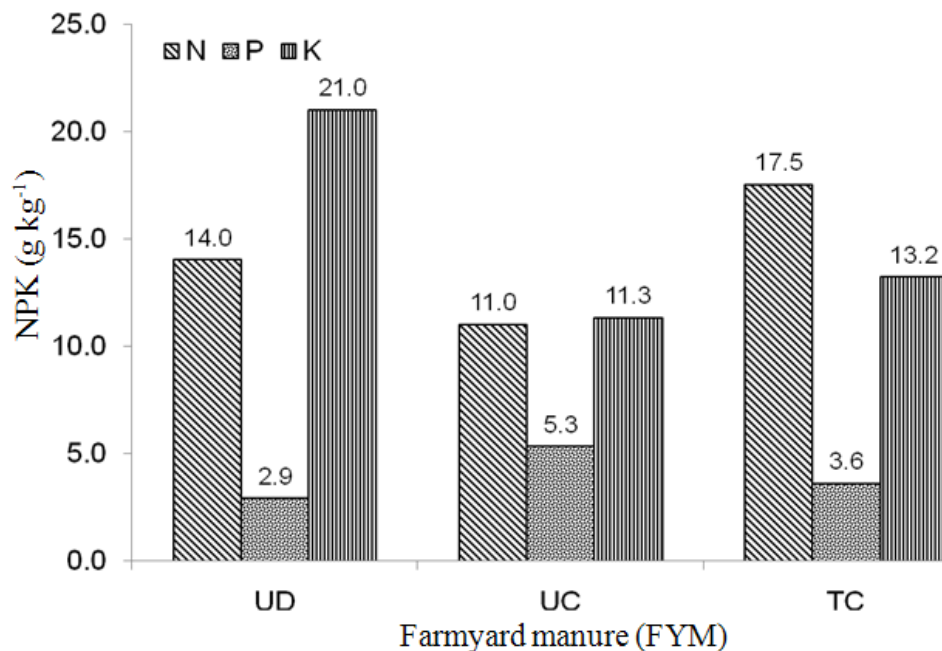


Figure 1. NPK contents of farmyard manure (FYM). UD, Un-decomposed; UC, untreated compost; TC, treated compost (with nitrogen 1 kg/pit).

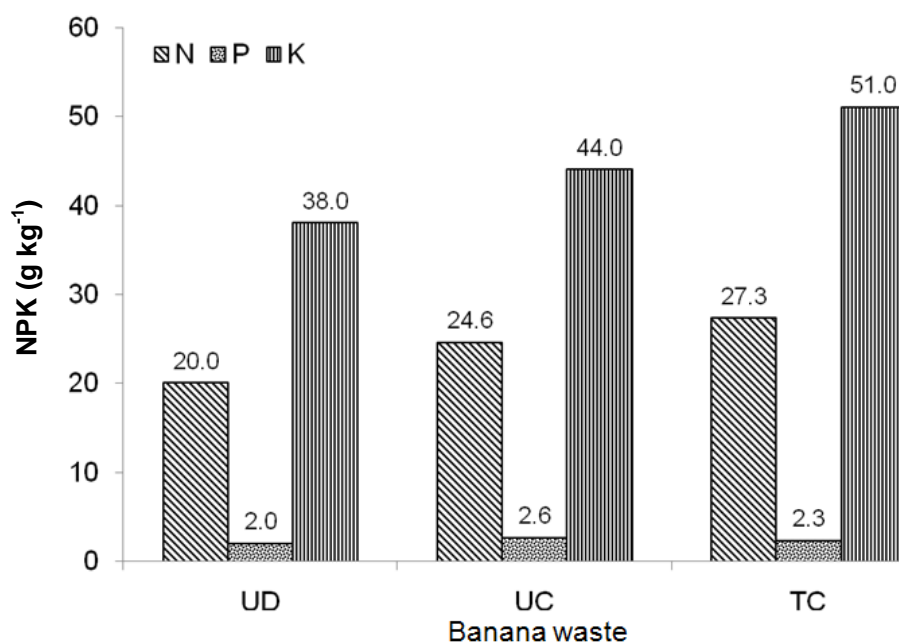


Figure 2. NPK contents of banana waste (BW). UD, Un-decomposed; UC, untreated compost; TC, treated compost (with nitrogen 1 kg/pit).

TC material but in case of FYM, the contents were lower (13.2 g kg^{-1}) than the UD of FYM (21.0 g kg^{-1}).

These values are supported by Doran and Kaya (2003) who prepared a compost material from banana waste

and found the N, P, and K contents as 26.0, 1.7 to 2.0 and 31.4 to 41.5 g kg^{-1} , respectively. Satisha and Devarajan (2007) found out that untreated pressmud compost alone gave 13.6 g kg^{-1} N and after composting

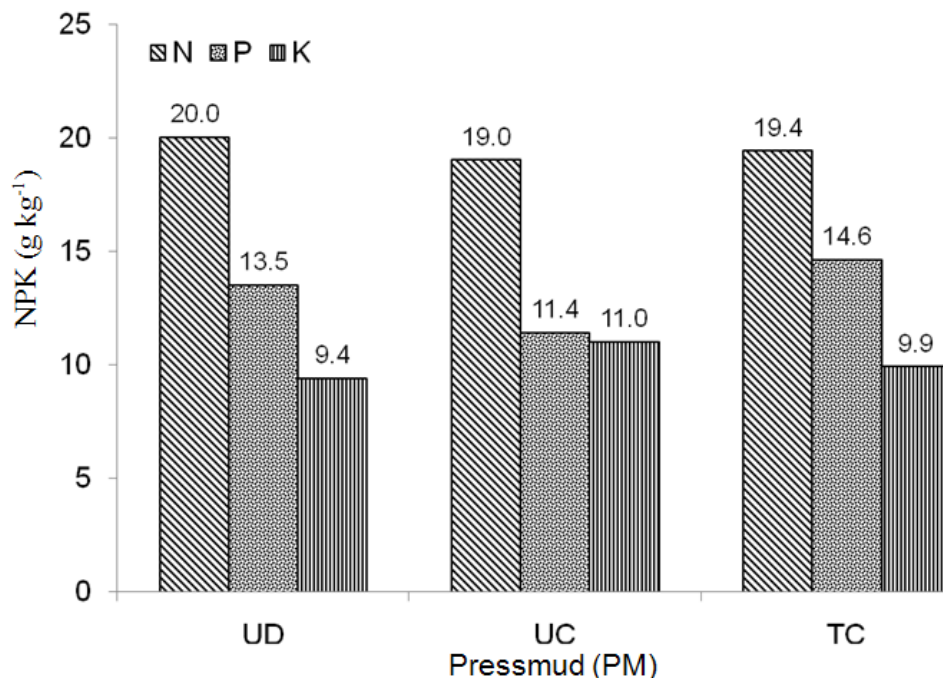


Figure 3. NPK contents of pressmud (PM). UD, Un-decomposed; UC, untreated compost; TC, treated compost (with nitrogen 1 kg/pit).

15.3 g kg⁻¹ N. Comparing the TC contents with UC, the N and K contents were higher in TC of FYM (17.5 g kg⁻¹), BW (27.3 g kg⁻¹) and PM (19.4 g kg⁻¹) than in UC of FYM (11.0 g kg⁻¹), BW (24.6 g kg⁻¹) and PM (19.0 g kg⁻¹). Whereas P was higher in TC of PM (14.6 g kg⁻¹) but very slightly lower in FYM (3.6 g kg⁻¹) and BW (2.3 g kg⁻¹) than in the UC of PM (11.4 g kg⁻¹), FYM (5.3 g kg⁻¹) and BW (2.6 g kg⁻¹). These results are in also agreement with the results of Rajendran (1991) who analyzed nutrient contents of FYM, pressmud compost, mushroom compost, coir pith compost and sawdust compost of southern India and found that composted pressmud without any treatment had the P contents as 22.0 g kg⁻¹ followed by FYM (3.0 g kg⁻¹).

Pot experiment

Soil properties

The soil used for pot experiment was a clay loam having pH, 7.86; EC, 0.36 dS m⁻¹; organic matter, 8.5 g kg⁻¹; Olsen P, 0.008 g kg⁻¹; and NH₄-acetate extractable K, 0.194 g kg⁻¹ soil.

Effect on plant height and dry matter yield of maize

Plant height

The data in Table 1 reveals significant increase in plant

height with the application of chemical fertilizers which was statistically similar for N, NP and NPK treatments. The addition of compost materials was not as effective as chemical fertilizers. In fact, the plant heights of UD-BW and UD-FYM were statistically equivalent to that of control and significantly less than control in case of UD-PM. It is however of interest to note significant increase in plant height over UD materials with addition of TC-PM or UC-PM. For other compost treatments, any increase in plant height was statistically non significant and plant height were similar to that for control treatment.

Dry matter yield

Application of N fertilizer increased dry matter yield of maize by 121% over control (Table 1). The application of P along with N increased it further to 133% over control. However, there was no effect of K addition on plant height. By comparison, application of composted materials showed a different trend in increasing dry weight of maize. When any of the three UD materials (FYM, BW and PM) were added, there was a decline in dry weights over control. Expressed on percent basis, respective dry weights were 70.08, 80.3 and 54.5% of that obtained for control treatment. The depressing effect of UD materials was reversed into beneficial effects when these materials were added after composting (UC) and treatment with N (TC). This positive effect of UC and TC treatments was statistically higher in dry matter yield of 55 and 70% over

Table 1. Plant height and dry weight (g pot^{-1}) of maize as affected by composted farmyard manure (FYM), banana waste (BW), pressmud (PM) and fertilizer treatments.

Treatment		Plant height (cm)	Dry weight (g pot^{-1})
T1	Control (0)	66.5 ^{bc}	20.9 ^f
T2	N*	81.0 ^a	46.3 ^b
T3	NP*	84.2 ^a	48.7 ^a
T4	NPK*	86.4 ^a	49.7 ^a
T5	UD-FYM ⁺	61.3 ^{bcd}	14.8 ^h
T6	UC-FYM ⁺	65.7 ^{bc}	21.6 ^{ef}
T7	TC-FYM ⁺	66.0 ^{bc}	32.3 ^d
T8	UD-BW ⁺	60.6 ^{cd}	16.8 ^g
T9	UC-BW ⁺	64.4 ^{bc}	17.8 ^g
T10	TC-BW ⁺	65.7 ^{bc}	18.3 ^g
T11	UD-PM ⁺	55.5 ^d	11.4 ⁱ
T12	UC-PM ⁺	65.8 ^{bc}	23.0 ^e
T13	TC-PM ⁺	67.7 ^b	35.6 ^c

*N-P₂O₅-K₂O as 75-37.5-30 mg kg⁻¹; FYM⁺, farmyard manure; BW⁺, banana waste; PM⁺, pressmud (all applied at the rate of 5 g kg⁻¹ soil); UD, un-decomposed; UC, untreated compost; TC, treated compost (with nitrogen 1 kg/pit).

control in case of FYM and PM respectively.

In general, both the plant height and dry matter yields showed significant improvement when UC and TC of BW, FYM and PM were added, although the response was much lower as compared with that obtained with chemical fertilizers. These results are in agreement with the results of Boateng et al. (2006) and Kannan and Prasanthrajan (2008) for poultry manure on growth and yield of maize.

Total N content of maize shoots

Total N contents of maize showed a wide range of variability from 9.7 to 20.6 g kg⁻¹ (Table 2). The application of N fertilizer more than doubled the N content from 9.7 to 20.6 g kg⁻¹ which stayed similar (20.0 g kg⁻¹) with the application of K, but showed significant decrease to 18.6 g kg⁻¹ when P was applied along with N. Similar results were observed when N fertilizer was applied alone in triticale (Lestingi et al., 2010) or with pressmud in sugarcane (Sharma et al., 2008), with FYM compost in lettuce (Stopes et al., 2003), with FYM in maize (Shah et al., 2010) and with city waste compost in paddy and straw of rice and grain of wheat (Mehdi et al., 2011).

The UD-FYM (T5) increased the N content from 9.7 g kg⁻¹ for control to 12.9 g kg⁻¹, whereas UD-BW and UD-PM did not influence the N content of maize. Meanwhile, there was significant improvement in N contents when composted materials were added. UC-BW and UC-PM (T9, T12) showed significant increase in N, whereas UC-FYM (T6) showed N content similar to that of untreated control. This was perhaps due to dilution effect resulting from increased dry matter yield. In case of treated

compost materials, TC-FYM (T7) showed highly positive increase in N content to 17.5 g kg⁻¹, followed by TC-PM (T13, 16.7 g kg⁻¹ N), while BW compost proved to be inferior source of increasing N contents to 11.6 g kg⁻¹ (T10).

Total P content of maize shoots

Total P in maize shoots ranged from 1.3 to 2.4 g kg⁻¹ for various treatments. Comparison of the data for various treatments given in Table 2 shows that P application coupled with N and K (T3 and T4) significantly increased P contents over control (T1) treatment. The application of PM also proved to be equally beneficial source in improving the P content of maize. It may be noted that the highest increase in P content occurred where either NP or NPK fertilizer (T3 and T4, respectively) was applied or UC-PM and TC-PM (T12 and T13, respectively) had been applied. Preusch et al. (2002) and Amoding et al. (2011) also reported higher plant P contents when nitrogen was applied in combination with rich P compost. The composts of BW and FYM were relatively inferior source of improving P contents of maize.

Total K content of maize shoots

The data regarding K content of maize shoots (Table 2) shows that the values ranged from 5.2 g kg⁻¹ K for untreated control (T1) to 25.1 g kg⁻¹ K (T4), indicating a highly positive response to K application. Application of N (T2) or NP treatment (T3) showed significant increase in K over control from 5.2 to 10.5 g kg⁻¹, but it was not even

Table 2. Total N, P and K contents of maize shoots as affected by composted farmyard manure (FYM), banana waste (BW), pressmud (PM) and fertilizer treatments.

Treatment		N (g kg ⁻¹)	P (g kg ⁻¹)	K (g kg ⁻¹)
T1	Control (0)	9.7 ^g	1.4 ^c	5.2 ^f
T2	N*	20.6 ^a	1.8 ^{cd}	9.3 ^e
T3	NP*	18.6 ^b	2.4 ^{ab}	10.5 ^{de}
T4	NPK*	20.0 ^a	2.5 ^a	25.1 ^a
T5	UD-FYM ⁺	12.9 ^d	1.3 ^e	10.7 ^{de}
T6	UC-FYM ⁺	10.2 ^g	1.7 ^d	18.3 ^b
T7	TC-FYM ⁺	17.5 ^{bc}	1.9 ^c	14.3 ^c
T8	UD-BW ⁺	9.6 ^g	1.3 ^e	11.3 ^{de}
T9	UC-BW ⁺	10.8 ^{ef}	1.7 ^d	12.1 ^d
T10	TC-BW ⁺	11.6 ^e	1.8 ^{cd}	15.6 ^c
T11	UD-PM ⁺	10.2 ^{fg}	1.8 ^{cd}	9.9 ^e
T12	UC-PM ⁺	11.5 ^e	2.3 ^b	11.3 ^{de}
T13	TC-PM ⁺	16.7 ^c	2.4 ^{ab}	23.3 ^a

*N-P₂O₅-K₂O as 75-37.5-30 mg kg⁻¹; FYM⁺, farmyard manure; BW⁺, banana waste; PM⁺, pressmud (all applied at the rate of 5 g kg⁻¹ soil); UD, un-decomposed; UC, untreated compost; TC, treated compost (with nitrogen 1 kg/pit).

50% of the K content achieved with K fertilizer application (T4). The composted treatments increased K contents according to the nature of material used for composting. TC-PM showed highest increase in K content (from 5.2 to 23.3 g kg⁻¹) followed by TC-FYM (T7- 14.3 g kg⁻¹ K). By comparison, UD-FYM (T5), UD-BW (T8) and UD-PM (T11) were less effective but showed statistically similar response which was equivalent to twice as much K% in each case compared to control (T1) treatment. There was further improvement in K content of maize when any of the three materials were added as UC-FYM, UC-BW and UC-PM (T6, T9 and T12, respectively).

The results clearly reveal that FYM, BW and PM were the rich sources of macro and micronutrients (data not presented) besides their organic matter contents. These results are in agreement with those given by Nehra and Hooda (2002), Alam et al. (2003), Shah and Anwar (2003), Hamdard et al. (2004) and many others. On comparative basis, PM was the richest source of P, whereas K was highest in BW. Composting of these materials generally improved their nutrient contents, which can also help in improving growth and yield of crops. Jamil et al. (2008) conducted a study on calcareous soils of Dera Ismail Khan and applied pressmud as organic amendment to mung bean and lentil crops in pots. They applied 2, 4, 6, 10, 15 and 20 tones of pressmud, including one treatment receiving recommended dose of N:P₂O₅:K₂O (30, 60 and 45 kg ha⁻¹, respectively). Maximum yield of lentil was obtained with NPK treatment followed by where 20 tones of pressmud were applied. The concentration of N, P, and K, in addition to Cu, Fe, Mn and Zn was maximum where pressmud was applied at 15 and 20 tones ha⁻¹. Whereas Venecio et al. (2005) observed that if BW is combined with leguminous material and chicken manure, significantly higher N and P

mineralization is obtained along with higher contents of K.

Maize growth (plant height) and dry matter yields showed highly significant increase with the application of N, P and K fertilizers, whereby most of maize response could be attributed to N fertilization. None of organic amendments produced as much growth or dry matter yield as chemical fertilizers. On relative bases, application of UD-FYM, UD-BW and UD-PM was less effective. By comparison, application of composted FYM, BW and PM with or without urea treatment produced increased growth yields. Among them, PM compost was found to be superior source compared to FYM and BW compost.

Conclusions

Compost is a potential source of crop nutrition. Pressmud appears to be better material, followed by FYM and BW. The decision about its use requires consideration about its availability. Cropping should be avoided soon after application of organic materials, particularly after PM. Further studies may be conducted on different aspects of compost making so as to improve the final product for crop nutrition. Studies may also be conducted on the integrated use of various composts and mineral fertilizers to determine their role in crop nutrition and sustainable production.

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